The first record of freshwater fish from Bhutan was by McClelland (1839) who reported *Balitora brucei* Gray and *Schizothorax richardsonii* Gray from the 1835 Boutan (sic) expedition of William Griffith. Five fish species were subsequently recorded from Bhutan by Day (1889) as part of a larger work on the fishes of South Asia. The most comprehensive listings of the freshwater fishes of Bhutan till date by Dubey (1978), Dhendup & Boyd (1994), and Petr (1999) record 47 species, of which eight are alien. In a study of the fish diversity in the Bumdeling Wildlife Sanctuary, Bhattarai & Thinley (2005) recorded 52 species; with Dema (2007) adding *Triplophysa stoliczkai* (Steindachner) to the list of fish species found in Bhutan.

In comparison to the 520 species reported from the eastern Himalayan region (Allen et al. 2010), 213 from the Arunachal Pradesh in northeastern India (Bagra et al. 2009), and 296 species from northeastern India (Vishwanath et al. 2007) the number of fish species currently known from Bhutan is a gross underestimate. The paucity of information on the fish fauna of Bhutan is mainly attributed to the very poor representation of material in collections and the conservation regulations that prohibit fishing without a permit, making collection of fresh material difficult.

The major drainage systems of Bhutan from the east to west are the Dangmechhu and Mangdechhu (Manas), Punatsangchhu (Sankosh), Wangchhu (Raidak) and Amochhu (Toorsa), with all these rivers debouching into the Brahmaputra River in India. In the higher elevations, these rivers support very low fish diversity due to their low productivity (Dubey 1978). There are also lakes in Bhutan, with Brown Trout (*Salmo trutta fario* Linnaeus) introduced in high altitude lakes (e.g., Nobtshonapata located at 4092m in Haa District and Tshophu at 4405m in Paro District) and Common Carp (*Cyprinus carpio* Linnaeus) in the lower altitude lakes (e.g., Hokotsho in Punakha and Ada in Wangduephodrang).

Given our poor knowledge of Bhutanese ichthyofaunal diversity and the imminent threats to aquatic biodiversity arising from large hydropower
projects planned in all the major rivers of Bhutan, an assessment of freshwater fish diversity in Bhutan is not only timely, but also necessary. In this study, based on a rapid assessment of ichthyofaunal diversity in selected water bodies of Bhutan, we present a list of 91 fishes that are now known to occur in Bhutan.

Materials and Methods

We divided a topographical map of Bhutan into different grids and used convenience sampling to assess the ichthyofaunal diversity in each grid. Focus was given to subtropical (below 1000m) rivers under the assumption that the diversity is higher in warmer water bodies (Fig. 1). Sampling was carried out in both the monsoon and post-monsoon seasons to cover both migratory and residential species. We sampled with cast nets wherever possible, and conducted searches by hand for species with cryptic behaviour. Basic parameters of water like pH, dissolved oxygen, and temperature were recorded at the sampling sites. Geographical coordinates and altitudes were also recorded.

Morphometric data were measured to a tenth of a millimetre using a dial calliper. We used existing literature (Day 1889; Jayaram 1999; Ng 2006; Vishwanath et al. 2007; Ng & Kottelat 2008; Jayaram 2009; Fishbase 2012; Nepeshwar et al. 2012) to identify the species and sought experts’ advice wherever possible. For uncertain species, voucher specimens were prepared after euthanizing the fishes with 0.0001% clove oil solution and treating in 10% formalin (Li & Li 2007). After 1–2 weeks of fixation in formalin, the specimens were transferred to 70% alcohol. The specimens were catalogued and preserved as voucher specimens in the laboratory collection of the College of Natural Resources (CNR).

Results and Discussion

We collected and examined 66 species of fishes from different regions of Bhutan. In order to avoid repeated collections and support scientific studies in future, 135 specimens comprising 45 species were catalogued and preserved as voucher specimens. For small species that could not be tagged easily, digital photographs were taken and preserved without catalogue numbers. Here, we provide a list of 91 fish species confirmed as occurring in Bhutan. However, species from Dubey...
Annotated checklist

Order Anguilliformes
Family: Anguillidae
1. Anguilla bengalensis (Gray, 1831) (Image 1).
   Locality: Nyera-amachhu in Samdrup Jongkhar, Manas in Panbang (Zhemgang), Maokhola in Sarpang and Dhamdum in Samtse.

Order Cypriniformes
Family: Cyprinidae
2. Hypophthalmichthys molitrix (Valenciennes, 1844).
   Locality: Introduced in Sarpang and Samdrup Jongkhar.
3. Hypophthalmichthys nobilis (Richardson, 1885).
   Locality: Introduced in Sarpang and Samdrup Jongkhar.
   Locality: Diglai in Samdrup Jongkhar and Manas in Panbang (Zhemgang).
   Locality: Diglai in Samdrup Jongkhar.
   Locality: Manas in Panbang (Zhemgang).
   Locality: Serichhu in Salamji (Dagana) and Manas in Panbang (Zhemgang).
   Locality: Manas in Panbang (Zhemgang).
   Locality: Manas in Panbang (Zhemgang).
10. Danio rerio (Hamilton, 1822).
   Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.
11. Devario aequipinnatus (McClelland, 1839) (CNR 10002, CNR 11036 & CNR 11180).
    Locality: Dhamdum in Samtse, Dikchhu in Wangdue Phodrang and Diglai in Samdrup Jongkhar.
    Locality: Kalikhola in Sarang.
13. Puntius chola (Hamilton, 1822). Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.
14. Puntius sophore (Hamilton, 1822). Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.
15. Puntius ticto (Hamilton, 1822).
   Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.
16. Tor tor (Hamilton, 1822). Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.
17. Neolissochilus hexagonolepis (McClelland, 1839) (CNR 10002, CNR 11036 & CNR 11180).
    Locality: Dhamdum in Samtse, Dikchhu in Wangdue Phodrang and Diglai in Samdrup Jongkhar.
18. Labeo rohita (Hamilton, 1822). Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.
19. Labeo dero (Hamilton, 1822).
   Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.
20. Labeo pangusia (Hamilton, 1822).
   Locality: Budichhu in Tsirang.
21. Labeo dyocheilus (McClelland, 1839) (CNR 11058).
    Locality: Budichhu in Tsirang.
22. Labeo pangusia (Hamilton, 1822) (CNR 11058).
    Locality: Budichhu in Tsirang.
23. Semiplotus semiplotus (McClelland, 1839) (CNR 12120).
    Locality: Diglai in Samdrup Jongkhar.
   Locality: Introduced for aquaculture in Sarpang and Samdrup Jongkhar.
25. Catla catla (Hamilton, 1822).
   Locality: In aquaculture in Sarpang and Samdrup Jongkhar.
26. Labeo dyocheilus (McClelland, 1839) (CNR 12098).
    Locality: Diglai in Samdrup Jongkhar.
27. Labeo pangusia (Hamilton, 1822) (CNR 11058).
    Locality: Budichhu in Tsirang.
28. Labeo rohita (Hamilton, 1822).
    Locality: Introduced for aquaculture in Sarpang and Samdrup Jongkhar.
29. Bangana dero (Hamilton, 1822).
   Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.
30. Schizothorax molesworthii (Chaudhury, 1913).
    Reported by Dubey (1978), Dhendup & Boyd (1994), Petr
(1999), and Bhattarai & Thinley (2005), so no material was examined.


39. *Balitora brucei* Gray, 1830. Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.


42. *Schistura multifasciata* (Day, 1878) Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.


44. *Schistura scaturigina* McClelland, 1839. Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.


46. *Triplophysa stoliczkaei* Steindachner, 1866 (CNR 12181). Locality: Headwaters of Pachhu in Jangothang (Paro) and Mochhu in Lingshi (Thimphu).


49. *Botia dario* (Hamilton, 1822), Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.


51. *Mystus bleekeri* (Day, 1877). Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.


53. *Mystus vittatus* (Bloch, 1794). Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.

54. *Batasio batasio* (Hamilton, 1822). Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.

55. *Batasio fasciolatus* Ng, 2006 (CNR 11052). Locality: Manas in Panbang (Zhemgang).

Family: Siluridae

57. *Ompok pabda* (Hamilton, 1822). Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.


Family: Schilbeidae


Family: Amblycipitidae

60. *Amblyceps apangi* Nath & Dey, 1989 (CNR 11165).
Locality: Diglai in Samdrup Jongkhar.

Locality: Diglai in Samdrup Jongkhar.

Family: Sisoridae

62. *Gogangra viridescens* (Hamilton, 1822). Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattarai & Thinley (2005), so no material was examined.

Locality: Manas in Panbang (Zhemgang).

64. *Bagarius bagarius* (Hamilton, 1822). Locality: Nyera-amachhu in Samdrup Jongkhar and Manas in Panbang (Zhemgang). No materials were collected.

Locality: Amochhu in Phuntsholing (Chukha).

Locality: Dhamdum in Samtse.

67. *Glyptothorax* sp. (CNR 11144, Image 5).
Locality: Punatsangchhu in Wangdue Phodrang.

Locality: Diglai in Samdrup Jongkhar.

Locality: Dakpaichhu in Zhemgang.

70. *Parachilloglanis hodgarti* (Hora, 1923) (CNR 11194).
Locality: Dakpaichhu in Zhemgang.

Locality: Toebenerongchhu in Punakha.

72. *Pseudolaguvia ferula* Ng, 2006 (CNR 11154).
Locality: Kalikhola in Sarpang.

Family: Claridae

73. *Clarias gariepinus* (Burchell, 1822). Locality: Sewerage tank and Toorsa in Phuntsholing (Chukha). No materials were collected.

Locality: Sarpang.

Family: Heteropneustidae

75. *Heteropneustes fossilis* (Bloch, 1794).
Locality: Amochhu in Phuntsholing (Chukha).

Family: Olyridae

76. *Olyra cf. kempi* McClelland, 1842 (CNR 11050).
Locality: Manas in Panbang (Zhemgang).

Order Salmoniformes

Family: Salmonidae

77. *Oncorhynchus mykiss* (Walbaum, 1792).
Locality: Introduced in cold water hatchery at Haa (Norbu 2013).

78. *Salmo truta fario* Linnaeus, 1758 (CNR 11178).
Locality: Chamkharchhu in Bumthang.

Order Beloniformes

Family: Belonidae

79. *Xenentodon cancila* (Hamilton, 1822) (CNR 11048).
Locality: Manas in Panbang (Zhemgang).

Order Synbranchiformes

Family: Mastacembelidae

Locality: Manas in Panbang (Zhemgang).

Locality: Sarpang.

Order Perciformes

Family: Nandidae

82. *Badis badis* (Hamilton, 1822) (CNR 11145).
Locality: Manas in Panbang (Zhemgang).

83. *Badis* sp. (CNR 11162).
Locality: Manas in Panbang (Zhemgang).

84. *Nandus nandus* (Hamilton, 1822). Reported by
Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattacharjee & Thinley (2005), so no material was examined.

Family: Cichlidae

Family: Channidae
86. Channa amphibeus (McClelland, 1845). Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattacharjee & Thinley (2005), so no material was examined.

88. Channa punctata (Bloch, 1793) (CNR 10177). Locality: Crocodile farm in Phuntsholing (Chukha).
89. Channa striata (Bloch, 1793). Reported by Dubey (1978), Dhendup & Boyd (1994), Petr (1999), and Bhattacharjee & Thinley (2005), so no material was examined.

Order Tetraodontiformes
Family: Tetraodontidae

Although catfishes of the family Sisoridae were frequently recorded during the survey, they have not been reported in previous studies. While Glyptothorax striatus McClelland, G. cf. telchitta Hamilton, Exostoma labiatum McClelland, and Parachiloglanis hodgardi (Hora) are mostly found in the rivers of temperate Himalaya (between 1000 and 3000 m), G. cavia Hamilton was restricted to subtropical regions (below 1000m) only. Based on the illustrations provided, Glyptothorax reticulatum McClelland and Balitora brucei Gray reported by Bhattacharjee & Thinley (2005) are reidentified here as Parachiloglanis hodgardi Hora and Psilorhynchus homaloptera Hora & Mukherji respectively. From among the Siluridae, Pterocryptis cf. barakensis Vishwanath & Sharma was found below 500m. Other catfishes like the Amblyceps apani Nath and Dey, A. mangois Hamilton, and Olyra cf. kempfi McClelland were also common in the subtropical (below 1000m) region.

We examined a specimen of Heteropneustes fossilis Bloch in a private aquarium at Phuntsholing that was reportedly collected from river Toorsa. Similarly, the only specimen of Channa punctata Bloch that we examined was collected from the crocodile farm at Phuntsholing.

Likewise, a juvenile specimen of Macrognathus morehensis Arunkumar & Tombi was collected from River Manas during the monsoon.

The description of Garra species from the region (Viswanath et al. 2007; Nebeshwar et al. 2012) are inadequate for the diagnosis of Garra species found in Bhutan. Similarly, the taxonomic keys provided by Viswanath et al. (2007) and Jayaram (2009) are inadequate in resolving the taxonomy of the catfishes known from Bhutan.

Some non-native species were recorded during the survey. Onchorhynchus mykiss Walbaum was introduced in a hatchery at Haa in 2007 (Norbu 2013). It has not been released in the rivers of Bhutan yet, but its escape in the river nearby is suspected. Oreochromis mossambica Peters was collected from the crocodile farm at Phuntsholing; this species was probably introduced to Bhutan in the mid 1990s (Ram Bahadur, pers. comm.).

Clarias gariepinus (Burchell) is another introduced species found in a sewage system and river Toorsa at Phuntsholing. It was introduced through “tshethar” practice (a compassionate act of releasing live fish in river water to prevent killings, mostly practiced by Buddhist monks). Even the elderly people with religious inclination, other than the monks, buy live fishes from across the border town and release them in the river nearby. This method of introducing alien aquatic organisms has also been reported elsewhere (Ng & Tan 2010). The live fishes sold in the border towns of India adjoining Bhutan for such practices are imported from Bangladesh via Kolkata. Unless the people are educated on the ecological consequences of such practices, this may serve as a major avenue of the introduction of alien species into the freshwaters of Bhutan and will become a major threat to conservation of native species in the country.

Conclusion
This study records 91 fish species from Bhutan. As the survey was carried out mainly in the monsoon season, a more extensive sampling regime both temporally (covering the inter-monsoon period) and geographically (in other areas of the country not sampled during this survey) is necessary to gain a better understanding of the freshwater fish diversity of Bhutan.

Although Bhutan pursues conservation of native fish species fervently, this is hampered by the poor state of knowledge of the diversity. Compared to the number of species reported from adjoining areas, the list of species presented here is clearly a gross underestimate.
of the freshwater fish diversity of Bhutan. The rapid development sweeping over Bhutan and the planned mega-hydropower projects to harness 10,000 MW by the year 2020 (RGOB 2010) is expected to have a significant impact on the biodiversity of the country, making it imperative that a further understanding of Bhutan’s ichthyofaunal diversity is critically needed.

REFERENCES


